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FINAL REPORT

Reversal Processing of  
High Resolution Films Study

1 April 1965

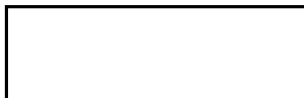


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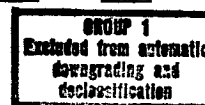
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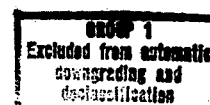
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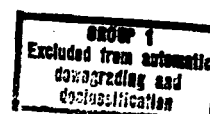
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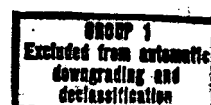
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### SUMMARY

Several different techniques are available for producing reversal effects in photographic materials, but the most widely used method is chemical reversal processing. In some reproduction applications, reversal processing can achieve increased resolution in duplicate copies by eliminating a printing operation; e.g., 2nd generation reversal duplicate negatives have significantly higher resolving power than duplicate negatives produced in a conventional negative-positive-negative system. When photographic interpretation is confined to a single positive record, the most information available for such an evaluation is supplied by reversal processing the original camera film. The superiority of these images over conventional 2nd generation duplicate positives is substantial for some films. Acquisition film types 4400, 4401, and 4404 and duplication film type 8430 were all found to be suitable for reversal processing; processing cycles were established for each. Resolving power data related to practical usage conditions were generated for each film type. Recommendations are made for further action; e.g., flights should be made to obtain typical exposures for picture tests.

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SUBJECT: Reversal Processing of High Resolution Films Study

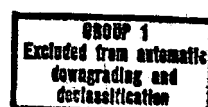
### TASK/PROBLEM

1. Investigate and develop reversal techniques for high resolution original negatives, duplicate positives, and duplicate negatives. Process to accomplish reversal with minimum loss in resolution.

### INTRODUCTION

2. Photographic Reversal Effects: Photography is normally considered as a negative system in that an increase in exposure causes a decrease in the amount of light available for viewing an image because of an increase in developed silver (density). There are several photographic processes, however, which produce the opposite effect. That is, an increase in exposure appears in the processed image as a decrease in density. Processes which cause this latter effect are commonly grouped together under the heading of reversal processes and includes such dissimilar subjects as the Clayden Effect, Solarization, and the Kodak Ektachrome Process. The reversal process method which has had by far the most application uses normal development followed by bleaching-out of the developed image of one polarity and re-exposure and re-development to bring out the image of opposite polarity. The use of normal processing equipment and chemicals, and the broad latitude permitted in the control of most processing steps, have made this chemical reversal method more desirable in some duplication applications than the negative-positive method which requires two precisely controlled processing systems and a printer. For these reasons, the subject study was limited to this particular reversal technique, and for the remainder of the report discussion on reversal processing will refer to this method.

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3. Mechanism of Reversal Processing: In reversal processing, the negative silver image produced in a first development step is dissolved out in a bleach, leaving a complimentary positive image which is developed to a metallic silver positive in the second developing bath. In this way, the negative and positive images are produced successively in the same emulsion layer. The inverse relationship between the negative and positive images is illustrated diagrammatically in Figure 1, which shows the essential steps:

- a. Exposure to form a latent (negative) image.
- b. Development of the negative silver image.
- c. Removal of this image by bleaching.
- d. Development of a positive silver image from the remaining silver halide grains.

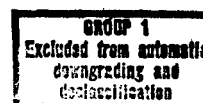
4. Applications for Reversal Processing: Reversal processing in a photographic system can be used to produce original positives from camera films, 2nd generation negative duplicates of original negatives, and 3rd generation positive duplicates of 2nd generation positives. There are other possible applications but most have no practical value. Properly designed reversal processing machines could also be used for negative and some color processing.

### DISCUSSION

5. General Test Plan: All tests were designed around a reversal processing cycle. The testing procedure was essentially the same for all the film types.

- a. Unusual or complicated techniques of reversal processing films were considered beyond the scope of the program. The main steps for each film were:

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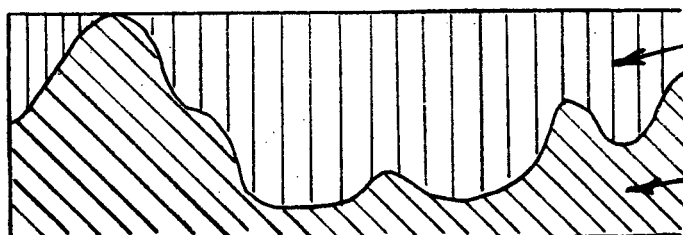


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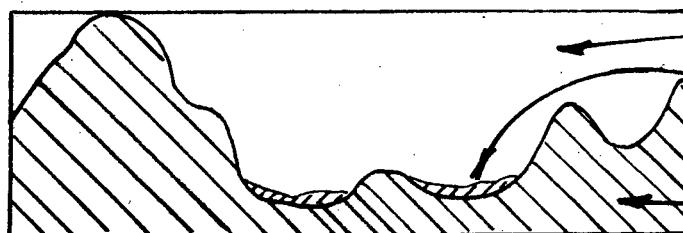
Film Cross Sections



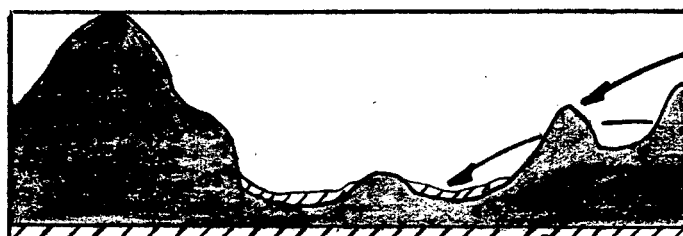
(a) Exposure



(b) Negative development



(c) Removal of the negative silver image



(d) Redevelopment of the residual positive image

Figure 1. Major Steps in Chemical Reversal Processing

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(1) Sensitometric and resolving power exposures were made.  
(2) Suitable chemicals for processing each film were selected.  
(3) Factorial experiments involving large changes in processing times and temperatures, re-exposure levels, chemical concentrations, etc., were conducted.

(4) From the data obtained in step 3 more refined experiments were designed.

(5) Processing conditions which produced satisfactory or the best possible sensitometric results were established. Resolving power exposures were processed at these conditions.

(6) Processing conditions were varied, more resolving power exposures were processed, and an evaluation was made to determine if the variation introduced improvement.

(7) The processing condition which produced the maximum value of resolving power was selected as the recommended process method.

b. Findings from the above were employed to generate original positives from camera originals as well as duplicate negatives printed from negative originals.

6. a. Only the films which met the requirements of high altitude reconnaissance systems were tested. Those that received extensive testing were as follows:

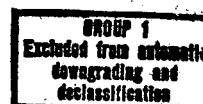
(1) Acquisition Film Types

- (a) Type 4404, Kodak High Definition Aerial Film
- (b) Type 4400, Kodak Panatomic-X Aerial Film
- (c) Type 4401, Kodak Plus-X Aerial Film

(2) Duplicating Film Types

- (a) Type 8430, Kodak Fine Grain Aerial Duplicating Film

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b. Type SO-233, a low contrast aerial duplicating film was included in the early stages of the program but failed to show promise. An attempt to establish Plus-X Reversal Film (Type 7276) as a reversal control emulsion was unsuccessful because it required much different processing from the other types. Film Type SO-107, Kodak Special High Definition Aerial Duplicating Film, was not included because previous work had shown that unconventional processing techniques (low-level pre-processing flashing or a prebath in a weak fix solution) were necessary to achieve reasonably satisfactory results. Film Type 5427, Kodak Aerographic Duplicating Film, was not tested since it is not suitable for duplicating the extremely high resolution films.

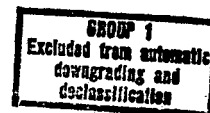
7. Chemicals: Only normal types of processing chemicals were used. Their formulae are listed in Appendix 1.

8. Processing:

a. Two immersion type processors were used in the investigation. One was a laboratory sensitometric processor and the other was a full scale production processor (Grafton). The basic sensitometric data for each film type was obtained on the sensitometric processor; the applicability of the data to production processing was verified on the Grafton; resolution data was collected with both.

b. The processing cycle for all of the film types was the same; develop, rinse, bleach, rinse, clear, rinse, re-expose (see paragraph c below), re-develop, rinse, fix, wash and dry. Factorial experiments involving variations in time (1st and 2nd developer), temperature and chemicals were conducted for each of the processing stages. Since the final sensitometric characteristics of each film type is almost entirely controlled by the conditions of 1st development, much more time was spent with this processing step than with the others.

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c. Re-exposure was accomplished both by timed exposure to light and by means of a chemical fogging agent (hydrazine sulfate). The two methods are compared in later discussion of the illustrated sensitometric effects shown in Figures 2 - 5.

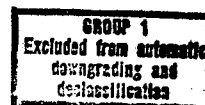
d. Reversal processing conditions (see Table 1) were varied only in the 1st development stage. All remaining steps were the same. These conditions were used on both sensitometric and full scale processors with the exception that the rinse stage after the clearing bath was not used on the full scale machine, since a rinse section was not available. Replenishment rates or the effects of spray processing were not investigated for any of the chemicals. These would have to be established for the particular type of processor used in any application.

### 9. Sensitometry:

a. Sensitometric exposures were made with a Model IV IB Sensitometer. The processed exposures were "read" on a Macbeth densitometer and the values were plotted on D-log E graph paper. The processing conditions for each film type were designed to produce a sensitometric curve which was as nearly as possible the mirror image of a negative curve for the same film. These were the most probable conditions for producing the highest resolution.

b. Sensitometric curves for all of the film types are shown in attached Figures: 4400 in Figure 2, 4401 in Figure 3, 4404 in Figure 4, and 8430 in Figure 5; a curve for a standard reversal process (using a light flash re-exposure) and a curve for a reversal process with chemical fogging are included in each. These curves represent the sensitometric conditions which existed when the reversal resolution data was collected. An examination of the figures will show the following:

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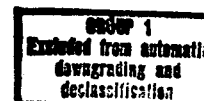
Stage	Formula or Condition at 75°F	Time	
		Min.	Sec.
Develop:			
8430	* Special Dev.	2	37"
4400	D-94	1	45"
4401	D-94	1	45"
4404	* MX-578	3	00"
The Remaining Data: all films			
Stop	SB5B	15	"
Bleach	R-9	30	"
Rinse	H <sub>2</sub> O	1	00"
Clear	CB-3	30	"
Rinse	H <sub>2</sub> O	1	00"
Re-expose	800-1200 fcs	---	
Re-develop light re-exposure	D-95	1	00"
Re-develop chemical fogging	FD-68	2	00"
Rinse	H <sub>2</sub> O	1	00"
Fix	F-6	2	00"

Table 1: Process Conditions for the Reversal Curves Shown in Figures 2 through 5.

\* Formula information is proprietary.

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Emulsion 4400

**EXPOSURE**

Sensitometer

Exposure Time

$$\log E_{11} = 2.70$$

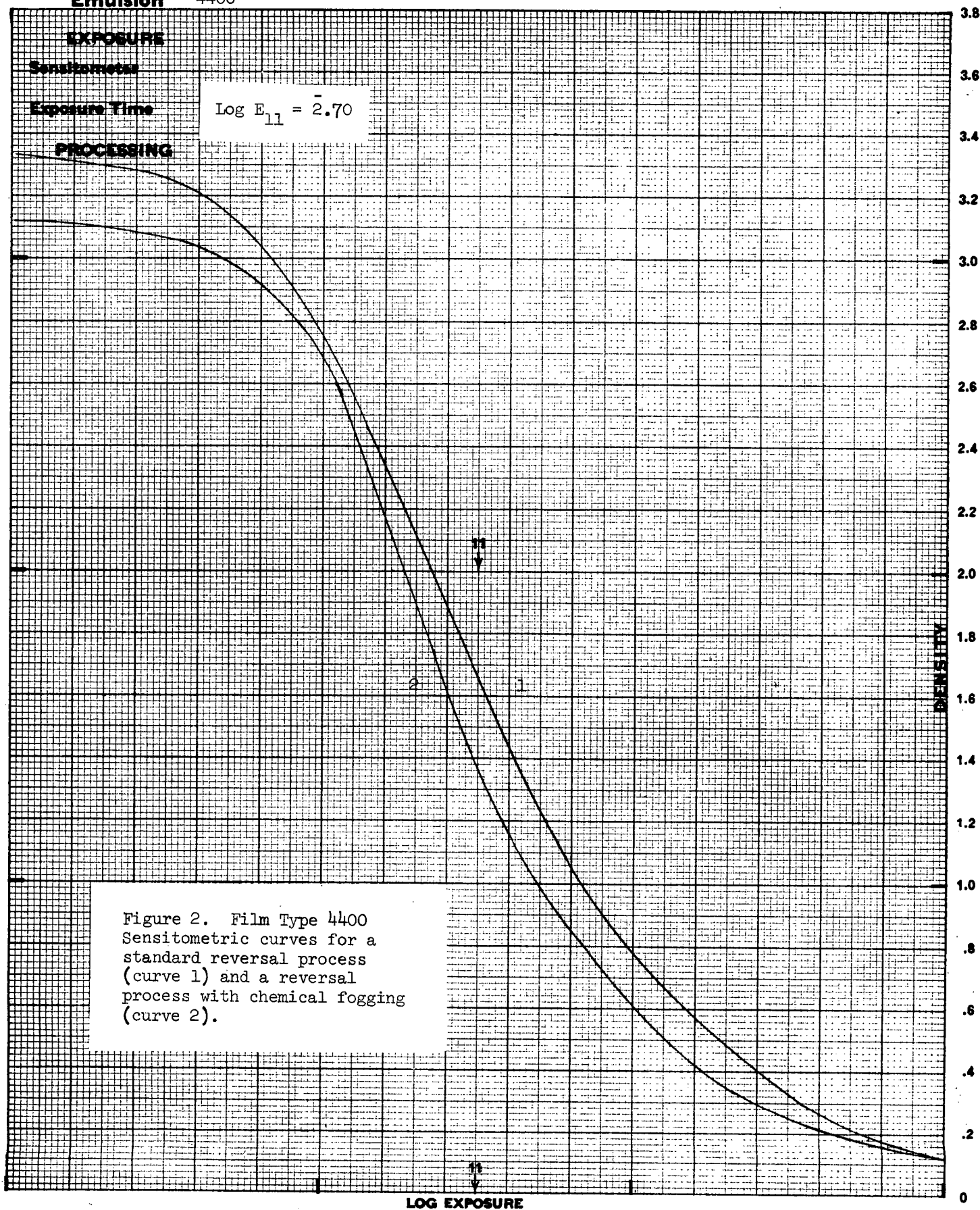
**PROCESSING**

Figure 2. Film Type 4400  
Sensitometric curves for a  
standard reversal process  
(curve 1) and a reversal  
process with chemical fogging  
(curve 2).

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Emulsion 4401

EXPOSURE

Sensitometer

Exposure Time

$$\text{Log } E_{11} = 2.70$$

PROCESSING

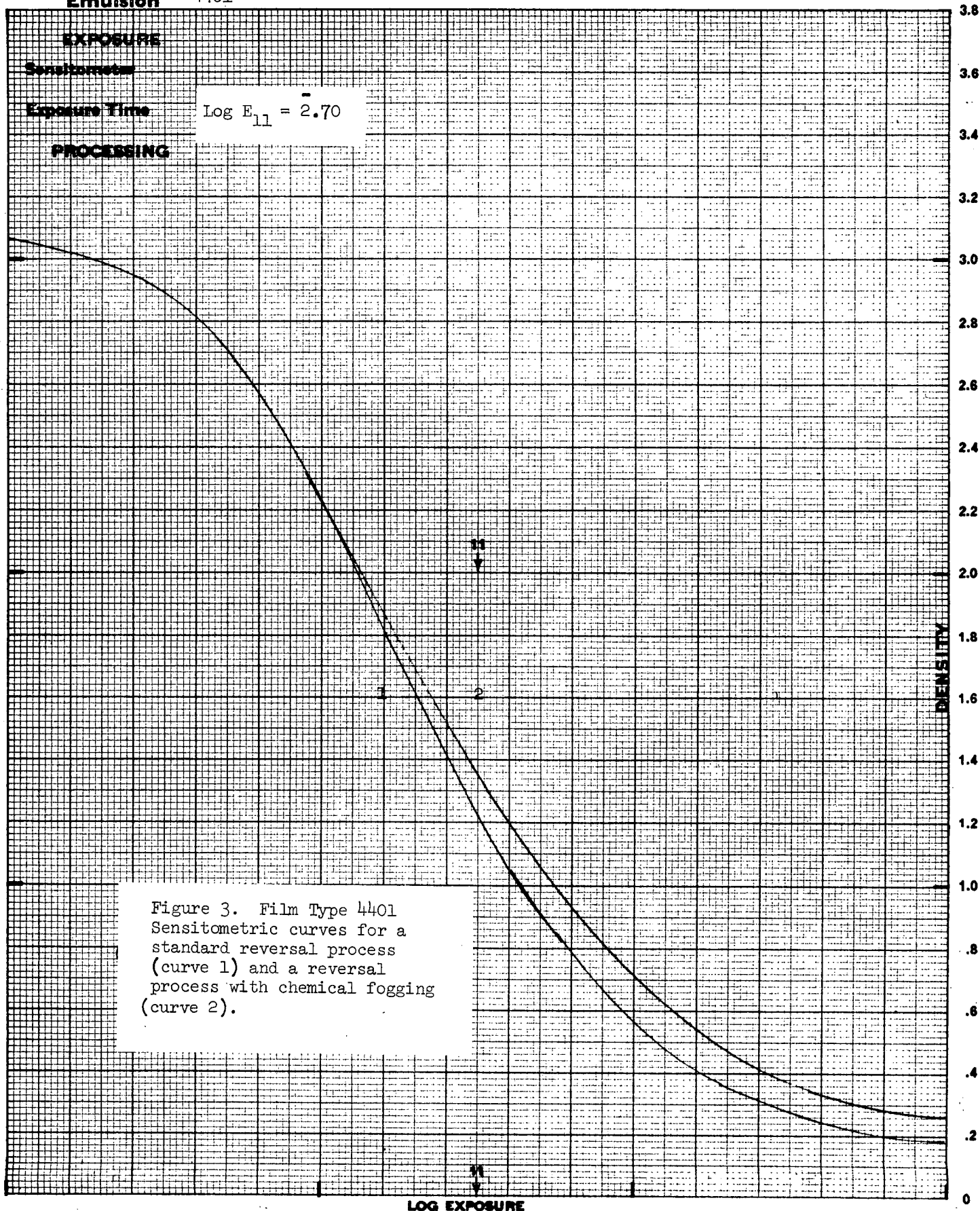


Figure 3. Film Type 4401  
Sensitometric curves for a  
standard reversal process  
(curve 1) and a reversal  
process with chemical fogging  
(curve 2).

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Emulsion 4404

EXPOSURE

Sensitometer

Exposure Time

PROCESSING

$$\log E_{11} = 1.30$$

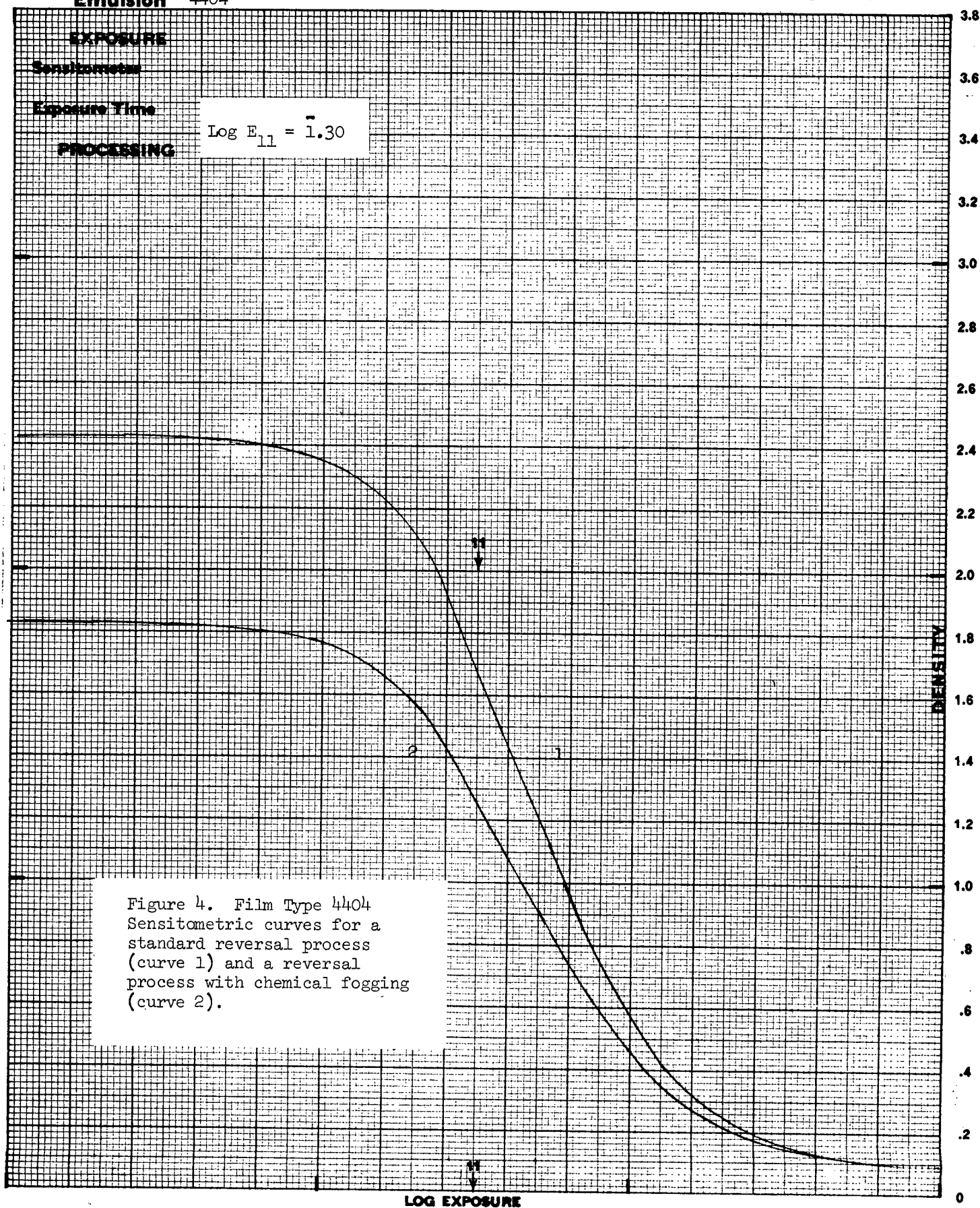


Figure 4. Film Type 4404  
Sensitometric curves for a  
standard reversal process  
(curve 1) and a reversal  
process with chemical fogging  
(curve 2).

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**Emulsion** 8430**EXPOSURE****Sensitometer****Exposure Time****PROCESSING**

$$\log E_{11} = 1.38$$

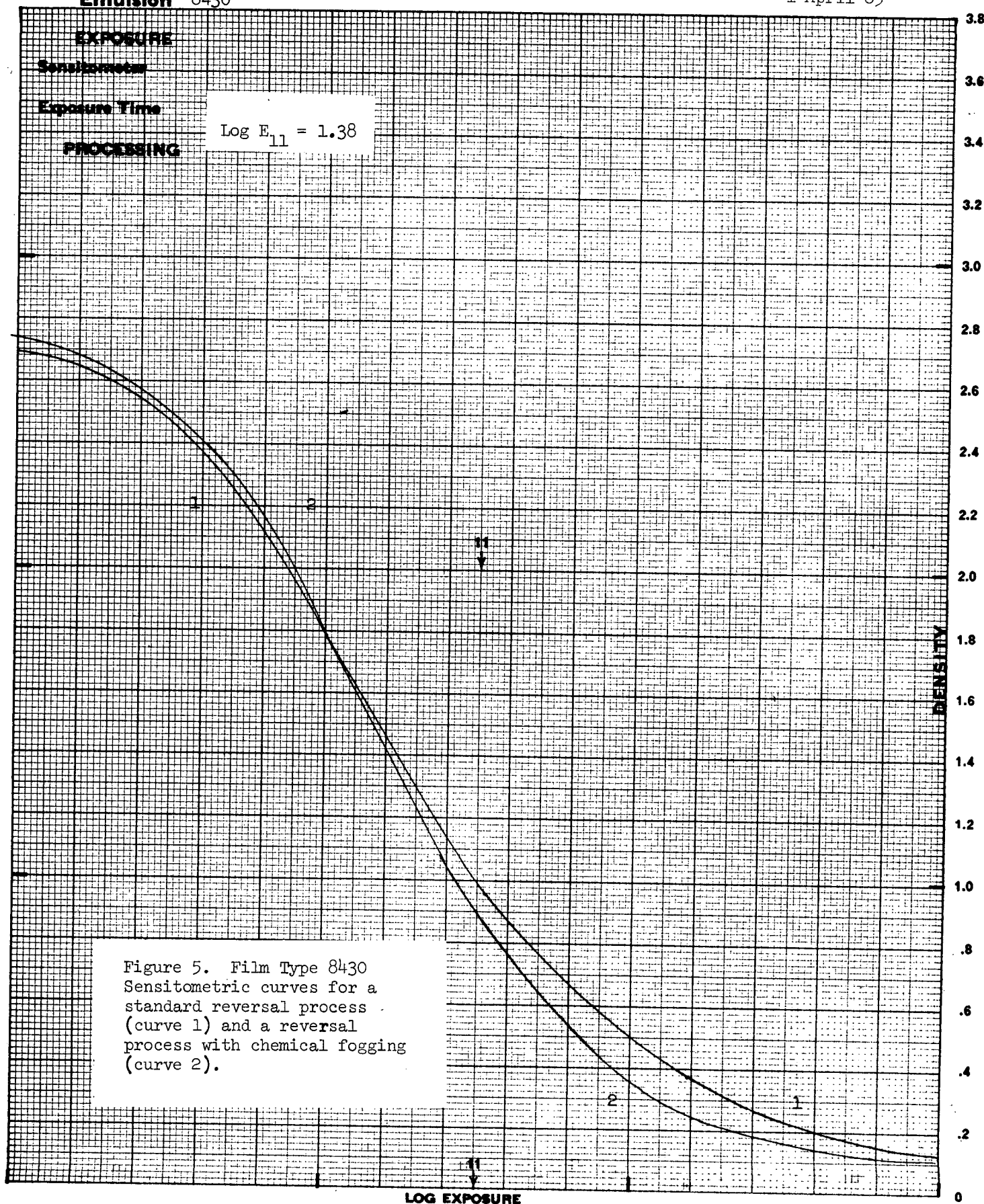


Figure 5. Film Type 8430  
Sensitometric curves for a  
standard reversal process  
(curve 1) and a reversal  
process with chemical fogging  
(curve 2).

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(1) The sensitometry for all the films is sufficiently good for practical application.

(2) The sensitometry for film types 4400, 4401 would be improved if the processed maximum density were lowered to about 2.40. (Viewing conditions for transparencies usually do not provide a light source with intensity sufficient to penetrate densities above 2.00.) Additional processing time in the 1st developer could accomplish this (actually over-development) but an unfavorable effect on image quality might result. Additional testing would be required to determine the extent of degradation, if any.

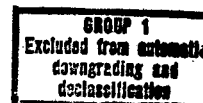
(3) The fogging agent used in the chemical reversal tests (hydrazine sulfate) would not react sufficiently with film type 4404 to produce the same maximum density as in the standard reversal process. This problem was unique with this one film type.

(4) The minimum base plus fog density for duplication film type 8430 is slightly higher (about 0.08 vs. 0.04) when reversal processed than when negative processed. This reduces the apparent contrast by a slight amount.

(5) The "printing speed" for film type 8430 is almost two stops faster when this film is reversal processed and compared to the negative process. (This is based on a Log E speed at 0.30 density units above fog for the negative process and 0.30 density units below D-max for the reversal process. The two log exposures values are 0.96 and 0.44 respectively, a difference of 0.52 Log E units.)

c. The reversal processed duplicate negatives, on the basis of tone and contrast, more closely resembled the original negative than did the duplicates from the negative-positive system. This was partly due to the number of duplication steps involved, since duplication frequently causes further contrast increase in the image midrange densities. Two duplication steps

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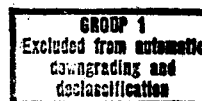
are needed in the negative process and only one in the reversal. Also, the higher minimum density in the reversal processed duplicates was closer to the minimum density of the original negatives. All of the films had a warm tone when reversal processed--the black and whites were not as brilliant as negative processed films. This difference is slight and is apparent only when samples from both processes are directly compared.

d. One important characteristic of reversal processed duplicate negatives is that they represent the mirror image of the original negative. Duplicate positives made from them via the negative process must be viewed through the base for correct orientation of the subject matter. All reversal duplicates thus need to be clearly marked to eliminate this possible source of confusion.

e. An additional set of reversal process curves is shown for film type 4404 in Figure 6. The three curves are analogous to the conventional three-condition negative process curves. (See Figure 7.) This film could be treated in a reversal process to compensate for changing exposure conditions in the same manner as it is in the three-condition interrupted negative process. The 0.6 gamma speed (measured on the shoulder of the reversal curves and the toe of the negative) for the reversal process are about 2/3 stop faster than for the negative process. No attempt was made to evaluate the resolving power at the three levels of development.

10. Methods of Evaluating Image Quality:

a. There are several methods available for assessing the information carrying capacity of films and systems. Some are objective and depend on photometric measurements (granularity, modulation transfer function, acutance, etc.) and some are subjective and depend on visual comparative estimates, (graininess, resolving power, uniformity, etc.).

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**Emulsion** 4404**EXPOSURE****Sensitometric****Exposure Time**

$$\log E_{11} = 1.30$$

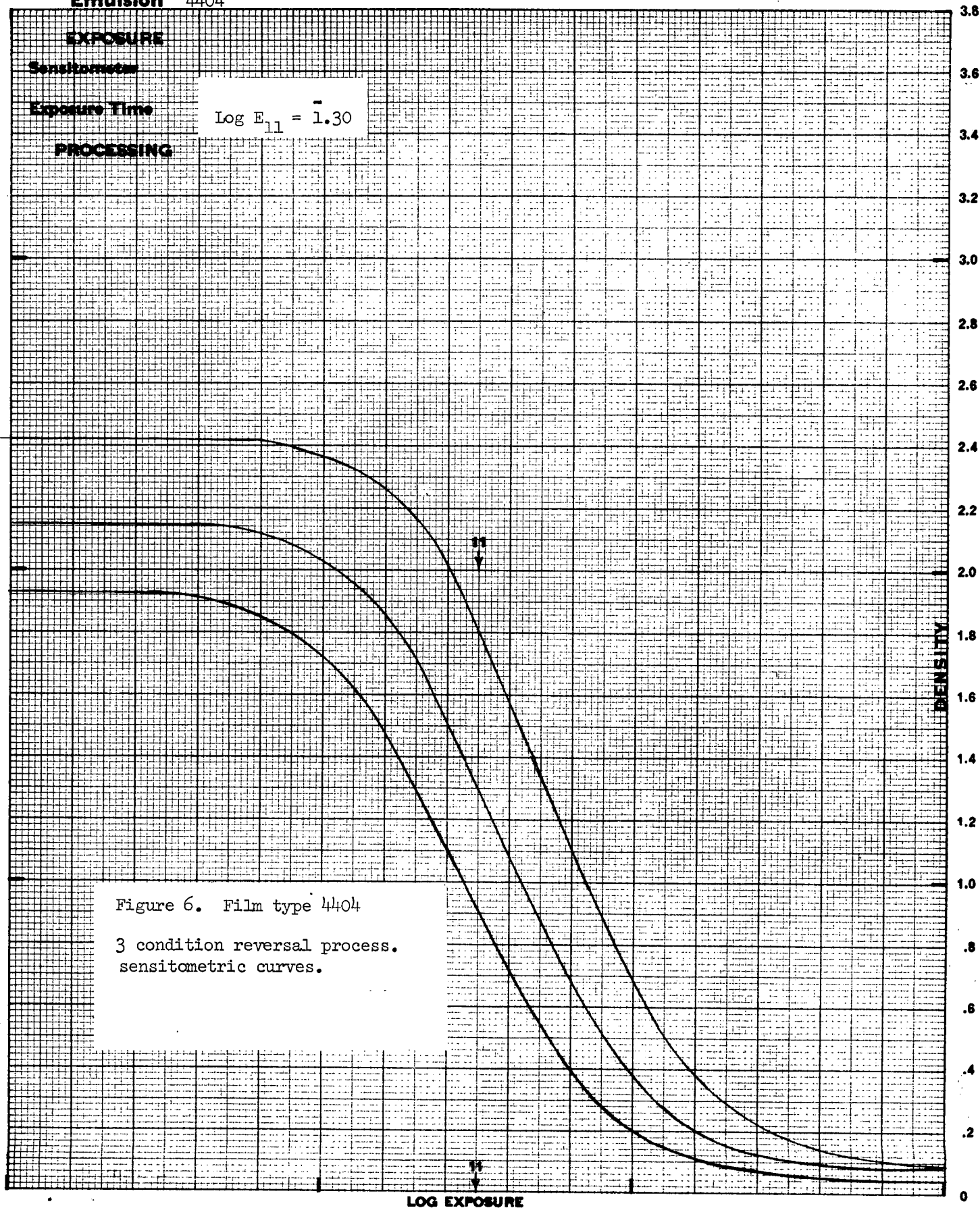
**PROCESSING**

Figure 6. Film type 4404

3 condition reversal process.  
sensitometric curves.**SECRET**Excluded from automatic  
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Emulsion 4404

EXPOSURE

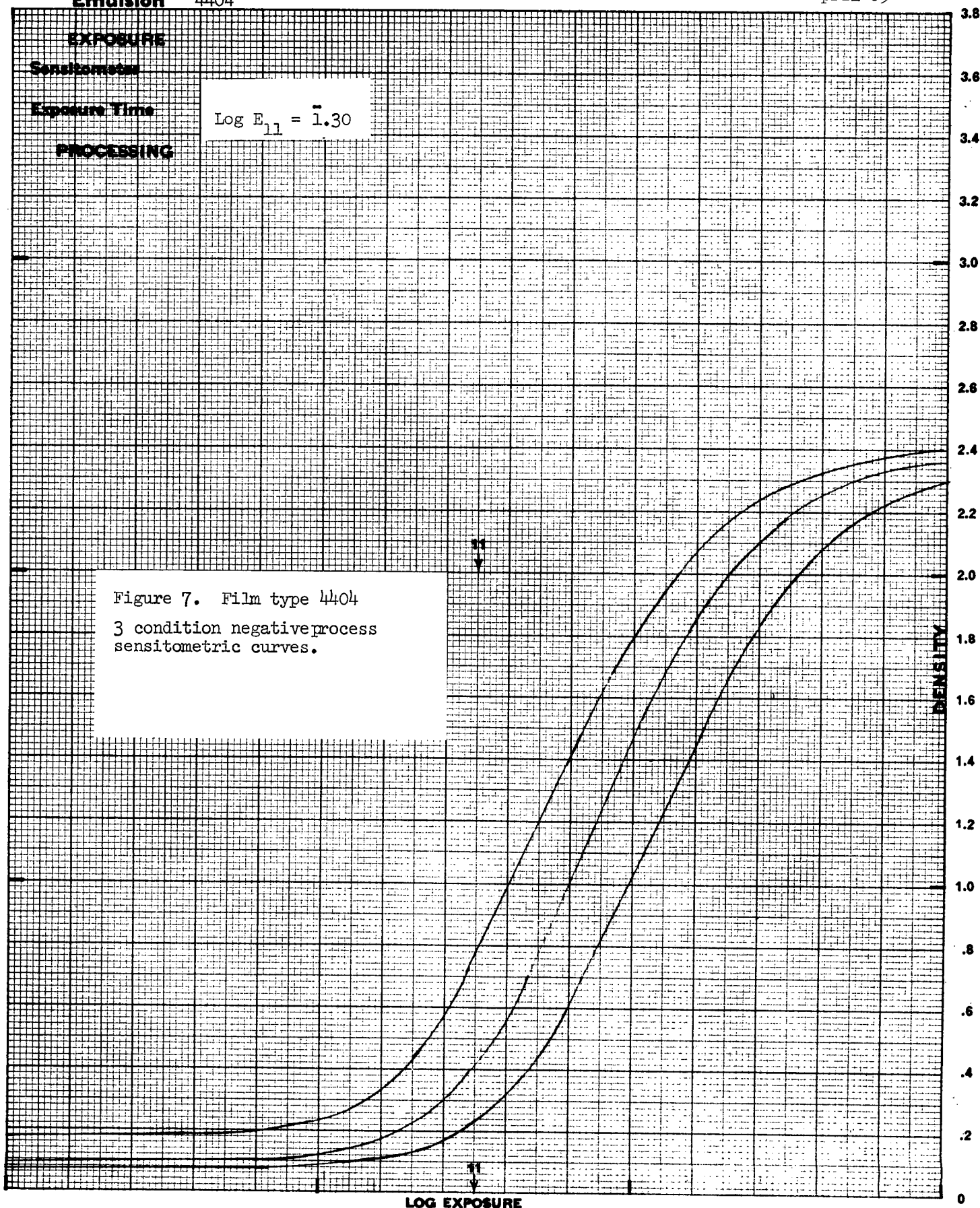
Sensitometer

Exposure Time

$$\log E_{11} = \bar{1}.30$$

PROCESSING

Figure 7. Film type 4404  
3 condition negative process  
sensitometric curves.



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b. Resolving power was used to the exclusion of the other methods because of the ease with which it can be measured and its practical significance as indicating the over-all performance of a material. Some of the others are more fundamental in an analytical sense but they are also much more difficult and expensive to utilize. The ability of a film to record fine detail can be rated in terms of resolution values. It is customary to report the resolving power of a film or system as the maximum value obtained. All of the common methods of image analysis and the individual advantages and problems of each are discussed in Reference 1.

11. Resolving Power:

a. The negative film resolution exposures were made with a Microscope Resolution Target Camera (Model II) which has a demonstrated capability of transmitting over 1000 l/mm. The duplication film resolution exposures were contact printed with UV light (General Electric bulb F6T5-BLB) on a Kodak Vacuum Register Board. The processed resolution exposures were examined with an Ernst Leitz Wetzlar microscope according to the directions in Reference 3. Magnifying power numerically equal to 50% - 75% of the resolution value was used to view the targets; e.g., for a resolution target of about 200 l/mm the viewing microscopic power was 100X to 150X. This was the criteria suggested in Reference 3 to obtain optimum viewing conditions and was found to be correct.

b. Two different target formats were used. One target had incremental differences in resolution magnitude between steps of 6% (12th root of 2) and the other had 12% differences (6th root of 2). Both are shown in Figure 8. The targets were used in both polarities--clear bar on dark surround and dark bar on clear surround. All targets were high contrast (1000:1).

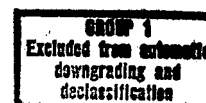
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Figure 8a

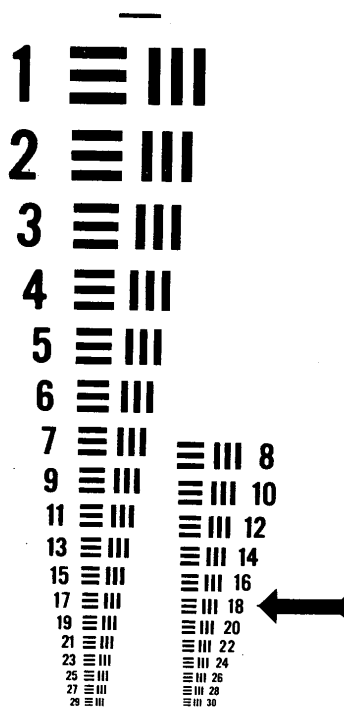


Figure 8b

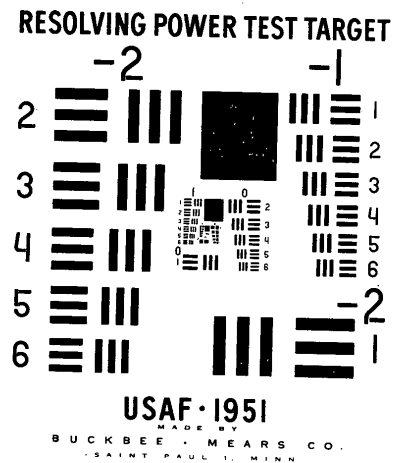


Figure 8. Resolving power test targets used to obtain the resolution data. The targets were used in both polarities; dark bar on clear surround (shown) and clear bar on dark surround. Figure 8a, a 12th root of 2 target, was specially prepared for this program; Figure 8b is a standard Buckbee Mears target.

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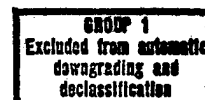
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c. The maximum value of resolution occurs (everything else constant) for one particular exposure level. For negative processed films this level occurs near the exposure related to the upper "toe" portion of the sensitometric curve. Since this maximizing condition cannot be precisely determined, an exposure series is required for each test. That is, a resolution test cannot be conducted with a single target exposure but requires at least eight targets covering a range of exposures with the probable maximum point occurring near the center of the range. When this situation is compounded with several film types, two polarities and several reproduction generations for each target, plus processing variations, a large number of exposures are required. About 500 individual targets were printed, processed and evaluated to obtain the data for this report.

d. Resolution values were obtained for each of the negative films and for successive generations on a duplicating film in a negative process and in reversal processes. The reversal processes were:

- (1) A standard cycle (light re-exposure).
- (2) A cycle with chemical fogging (no re-exposure by light).
- (3) A standard cycle which was preceded by a low intensity flash with UV light through the film base. This last method is referred to in the literature as Image Enhancement and theoretically can produce improved image quality in reversal processing by causing a portion of the silver halide near the lower part of the emulsion coating to be developed and bleached out. In this way the image is confined to the upper part of the emulsion layer.

e. The important resolving power values obtained in the study are shown in Tables 2 and 3. The arrangement in both figures is descriptive regarding the data collection procedure for the different generations. The values listed should be considered in a comparative manner within the context of the study and should not be applied indiscriminately to other processing

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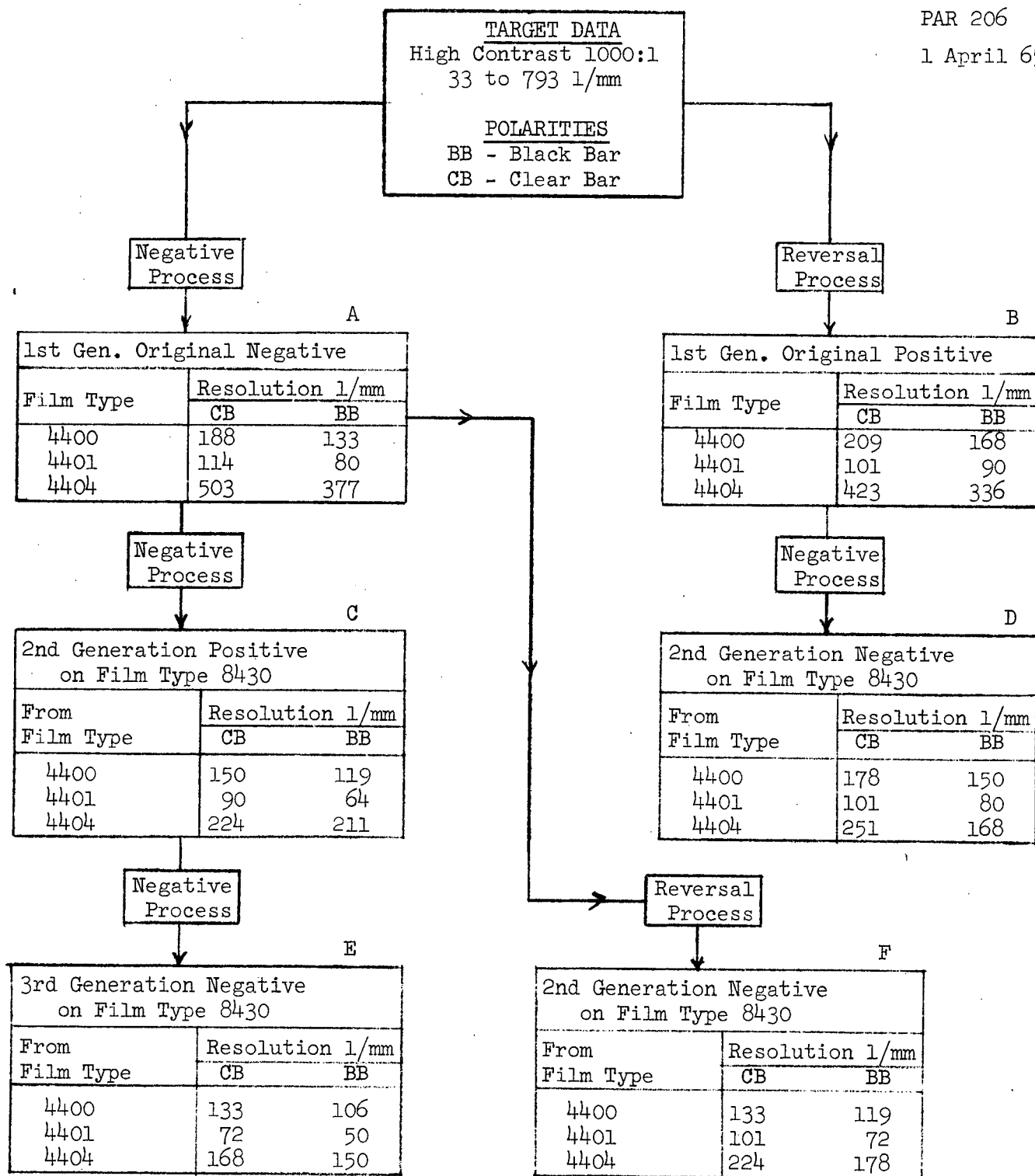
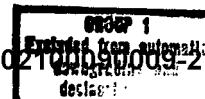


Table 2. Resolution values for Film Types 4400, 4401 and 4404 and for subsequent generations on Type 8430 Duplication Film.

Note: The symbols CB and BB are always in relation to the original polarity of the target and not the polarity at the various generation series levels shown.

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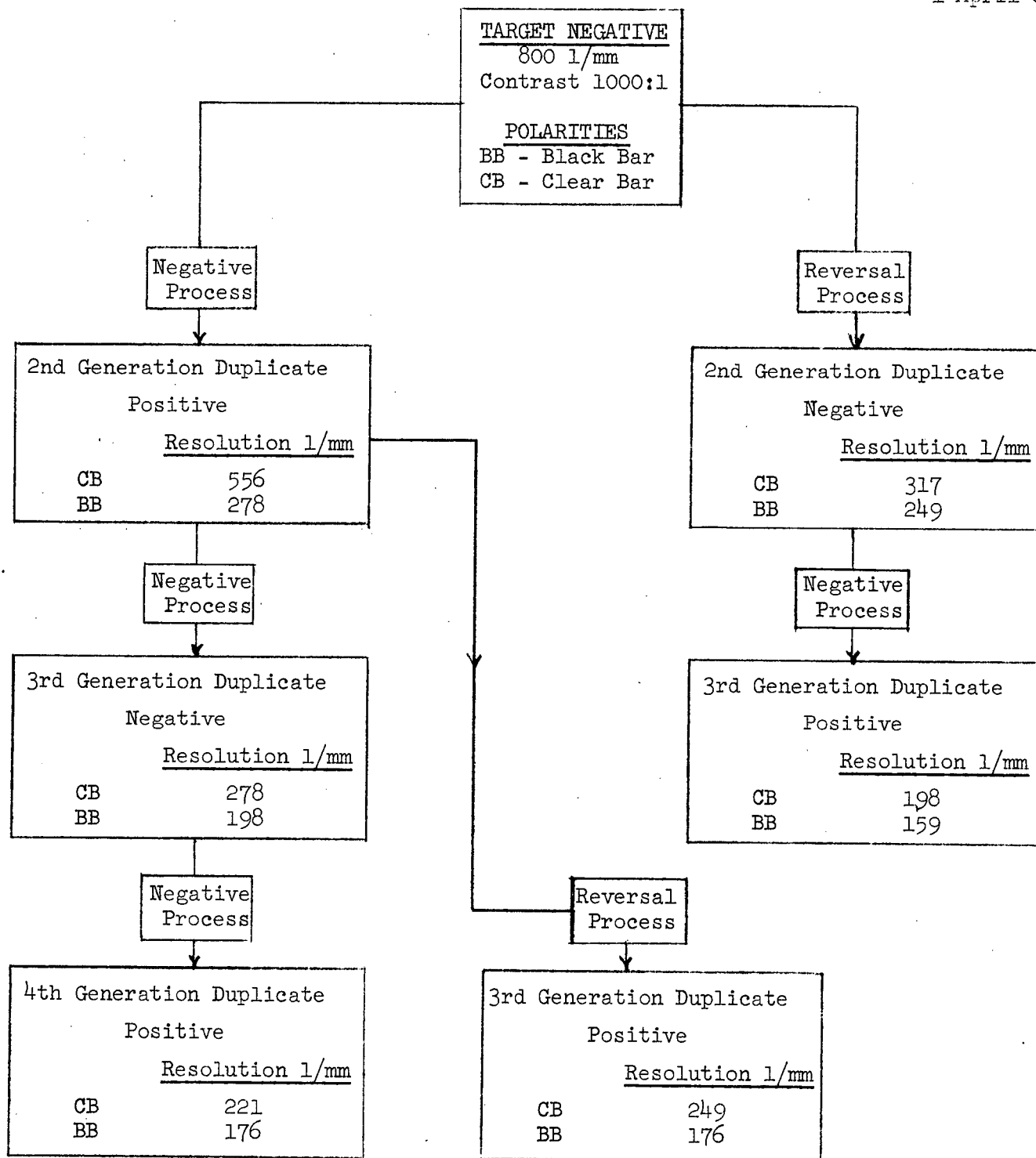


Table 3. Resolving power generation series for Type 8430 Duplicate Film.

Note: The symbols CB and BB are always in relation to the original polarity of the target and not the polarity at the various generation series levels shown.

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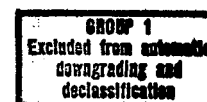
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resolution data. The primary importance of the data is to show trends or relative effects and not absolute evaluations. When the processed samples were obtained for each phase of the study no attempt was made at that time to assign numerical values, only to identify the best targets. The resolution values were assigned after all of the targets had been obtained and could be examined with a split-field comparative microscope.

f. The value of reversal processing can be illustrated by analyzing data found in Table 2. This Table shows how the resolving power changes during typical reproduction cycles. Resolving power targets were exposed onto film types 4400, 4401 and 4404 and processed in both negative and reversal processes. (Blocks A and B respectively.) Conventional duplicate positives (Block C) and negatives (Block F) were made of the original negative (Block A) onto duplication film type 8430. Also, conventional duplicate negatives (Block D) were made from the original positives (Block B). For each reversal process step, (Block B&F) the standard-light re-exposure, chemical fogging "re-exposure", and image enhancement process methods were used. In all cases, the standard-light re-exposure process produced duplicates with resolution values as good as or better than duplicates processed by the other two methods. Therefore, the results from standard reversal processing were used for the values in Table 2.

g. Resolving power targets were reproduced through several generations on Type 8430 to assess its capabilities independently of any particular camera film. These data were published in a PAR 206 report dated 30 November 1964. These data, shown in Table 3, more fundamentally represent the basic differences of negative and reversal processing as they effect resolving power. Essentially though, either set of measurements, Tables 2 or 3, confirms the resolution relationships shown in the other.

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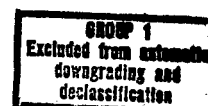
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### CONCLUSIONS

12. Several important conclusions can be drawn from the resolution measurements of Table 2. (The Block letters refer to the letters in Table 2):

- a. Resolving power of acquisition films which have been reversal processed to yield a positive (Block B) is significantly higher than the conventional 2nd generation duplicate positives made from a conventionally processed negative (Block C). For example, the original positive resolution of film type 4404 is 423 l/mm and the resolution (on film type 8430) of the 2nd generation duplicate is 224 l/mm. This scene difference holds for the other film types, but the magnitude is greatest for the films with higher resolution capability.
- b. The resolving power of 2nd generation reversal duplicate negatives (Block F) is equal or higher in all cases to the 3rd generation duplicate negatives processed in a conventional negative-positive system (Block E). This comparison was a major reason for making the study and it has been confirmed by every set of resolution data produced. Again, the magnitude of the difference is greatest for duplicates of films with higher resolving power.
- c. The resolving power of 2nd generation negative duplicates of original positives (Block D) is comparable to and for some films greater than the resolving power of 2nd generation reversal negative duplicates (Block F). This relationship is extremely important in the event that the acquisition film is reversal processed to obtain a positive image.
- d. The resolving power of film types 4400 and 4401 appears to be as good or better when reversal processed than when negative processed (Blocks A & B).

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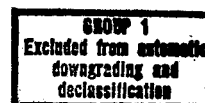
13. While several important aspects of reversal processing, duplication methods, and image analysis should be examined before any firm decisions are made, it appears, on the basis of the data presented, that reversal processing techniques can effectively supplement existing photographic systems. Of immediate application is the production of reversal duplicate negatives from the original negative. When such a copy is available, duplicate positives can be produced which are better in resolving power than 4th generation duplicate positives made conventionally from 3rd generation negatives.

14. Reversal processing the original acquisition camera exposures is the most challenging application of reversal processing. The advantages and disadvantages are obvious but vary in importance for different situations. When many people are required to evaluate large footages of film, many positive copies are also required. The usual and most practical method of obtaining these is from an original negative. However, the resolution of the 2nd generation copies is inferior to that which is obtainable in an original positive and, in fact, appears only slightly better than that of a reversal processed duplicate positive of an original positive based on these tests. When only one positive record is required, the camera film should be reversal processed if maximum resolution is essential. Reversal processing also offers the advantages of shortened access time; photographic interpreters could examine the film almost immediately instead of having an initial wait while the first positive copies were being made.

**RECOMMENDATIONS**

15. To assist in establishing the practicality and desirability of applying the conclusions to existing processing situations, several things should be done:

a. As we pointed out in the introduction, resolving power is a convenient tool for estimating system performance, but it is not conclusive

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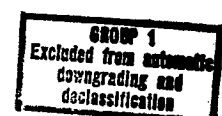
and should be used in conjunction with other methods of analysis. It is recommended that MTF (modulation transfer function), granularity, and acutance tests be made to supplement the resolution data. There are indications that the results of such tests should further enhance the practicality of reversal processing; MTF curves for some camera films have been higher for reversal than negative processing.

b. The final proof of the useability of any film or system is in the results of practical applications. For this reason, several flights should be made for the express purpose of providing typical exposures for use in picture tests. The processed films and copies should be evaluated by trained photographic interpreters.

c. Initiate feasibility studies for an interrupted (first development stage) reversal processor. This study would have as its objectives:

- (1) Determine design parameters.
- (2) Indicate practical versatility possible for color reversal and negative processing.
- (3) Estimate costs of fabrication.
- (4) Recommend most suitable system.

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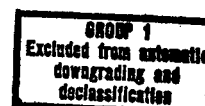
1 April 65

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1. Mees, C.E.K.; The Theory of the Photographic Process, The Macmillan Company, New York, 1942.
2. Ives, C.E., et. al.; Processing Methods for Use with Two New Black-and-White Reversal Films, SMPTE, Vol. 66, No. 1, pp. 1-11, January 1957.
3. Jones, R.C.; American Standard Method for Determining Resolving Power of Photographic Materials, Polaroid Corporation Research Division, 1963.
4. All previous PAR 206 reports
  - a. Monthly
    - 1 May 1964
    - 10 July 1964
    - 7 August 1964
    - 2 October 1964
    - 30 October 1964
    - 24 December 1964
    - 22 January 1965
    - 31 March 1965
    - 30 April 1965
  - b. Quarterly
    - 5 June 1964
    - 8 September 1964
    - 30 November 1964
    - 26 February 1965

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**SECRET**APPENDIX 1

## Chemical Formulae

Special Developer and MX-578 Developer:

(Formulae for the above developers are proprietary)

D-94 Developer

Elon -	0.6 g
Sodium Sulfite -	50 g
Hydroquinone -	20 g
Potassium Bromide -	8 g
Sodium Thiocyanate -	6 g
Sodium Hydrozide -	20 g
Water to Make -	1 liter

R-9 Bleach

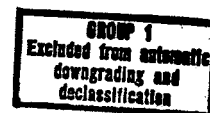
Water -	1 liter
Potassium Dichromate -	9.5 g
Sulfuric Acid (conc.) -	12 cc

SB5B Stop Bath

Acetic Acid -	35 ml
Sodium Sulfate -	45 g
Water to Make -	1 liter

CB3 Clearing Agent

Sodium Sulfite -	10 g
Water to Make -	1 liter

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**SECRET**APPENDIX 1 (Cont'd.)D-95 Developer

Elon -	1 g
Sodium Sulfite -	50 g
Hydroquinone -	20 g
Potassium Bromide -	5 g
Potassium Iodide -	0.25 g
Sodium Hydroxide -	15 g
Water to Make -	1 liter

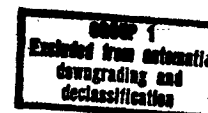
FD58 Developer

Elon -	2 g
Sodium Sulfite -	90 g
Hydroquinone -	8 g
Sodium Carbonate -	52.5 g
Sodium Hydroxide -	10 g
* Hydrazine Sulfate -	1 g
Water to Make -	1 liter

F-6 Fix

Sodium Thiosulfate -	240 g
Sodium Sulfite -	15 g
Acetic Acid (28%) -	48 cc
Kodalk -	15 g
Potassium Alum -	15 g
Water to Make -	1 liter

\* Caution: Hydrazine sulfate is an irritant. If contact with skin or eyes occurs wash with plenty of water immediately.

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MONTHLY REPORT

25X1

PAR 206

22 Jan 65

SUBJECT: Reversal Processing of High Resolution Films Study

## TASK/PROBLEM

1. Investigate and develop a reversal process for high resolution original negatives, duplicate positives, and duplicate negatives. Process to accomplish reversal with minimum loss of resolution.

## DISCUSSION

2. The high contrast (12th root of 2, black bar on clear surround and clear bar on black surround) resolving power targets were received. They were examined by the image analysis group and found to be satisfactory for use in this program. Their frequency range is from  $8^4$  to  $63^4$  lines/mm. The steps are separated by a multiplying factor of 1.06; that is, each step is 6 percent greater in frequency than the step immediately below it. This construction makes the 12th root targets twice as sensitive as the 6th root targets whose steps increase by 12 percent. Samples of all the targets used in the study will be included in the final report.

3. The 12th root of two targets will be reduced onto a special high resolution material for use in a contact printer. In this form, they can be used for a generation series with Type 8430 duplicating film. The 6th root of two targets are already available for this application.

4. Some resolution data, of a preliminary nature, has been collected, but there is nothing conclusive to report at this time. The resolution values obtained appear reasonable and indicate that the tests are proceeding along correct lines.

5. Three proposed designs for briefing aids were prepared for submitting to the customer.

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PLANNED ACTIVITIES

6. Complete collection and analysis of resolution data.
7. Initiate preparation of final report.

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